TG550

5 MHz Precision
Function Generator
Service Manual

Book Part Number 48591-0610 - Issue 1

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Specification

Specifications apply at 18º - 28º after one hour warm-up, at maximum output into 50Ω.

FREQUENCY

Frequency Range:	0·005Hz to 5MHz in 7 overlapping decade ranges with adjustment by coarse and fine verniers.
Vernier Range:	1000:1 on each range.
Frequency Display:	Auto-ranging reciprocal measurement giving 4-digit resolution down to 10Hz (to 1Hz on the 5Hz range); resolution is fixed at 0·01Hz below 10Hz (0·001Hz below 1Hz on the 5Hz range). Accuracy is ± 1 digit to 2·1Hz (to 0·21Hz, Symmetry off, or to 0·42Hz, Symmetry on, on the 5Hz range); below this the accuracy is ± 1% of range full scale (unspecified with Symmetry on).
Frequency Locking:	With vernier setting between 10% and 100% of range maximum, frequency can be locked to the crystal reference to maintain it at the displayed value ± 0·01%.

WAVEFORMS

Waveform specifications apply for the top decade of each frequency range.

SINE

Distortion:	Less than 0·5% on 500Hz, 5kHz and 50kHz ranges; less than 1% on 5Hz, 50Hz and 500kHz ranges; all harmonics >25dB below fundamental on 5MHz range.
Amplitude Flatness:	± 0·2dB to 200kHz; ± 2dB to 5MHz.

TRIANGLE

Linearity:	Better than 99% to 200kHz.

SQUAREWAVE

Rise and Fall Times:	<45ns.
Mark-Space Ratio:	1:1 ± 1% to 100kHz.

DC

Range:	± 10V (unterminated).

SYMMETRY

Symmetry Range:	Variable typically between 1:9 and 9:1 (on top decade of each range), frequency divided by 10 when Symmetry is selected.

MODULATION MODES

Modulation can be used with all waveforms and at any frequency.

Sweep

Sweep Mode:	Internal: linear or logarithmic; sweep Start and Stop frequencies displayed at a press of a button. External: linear.
Sweep Width:	Up to 1000:1 within each range.
Sweep Rate:	Internal sweep rate adjustable from typically 20ms to 20s.
External Sweep:	By signal applied by SWEEP IN/OUT socket.

Amplitude Modulation

Modulation Depth:	Variable 0 to 100% typical.
Modulation Frequency:	400Hz internal. DC to 100kHz external.
External Modulation:	By signal applied to COUNT/AM IN socket.

OUTPUTS

50Ω Main Out

Output Impedance:	50Ω.
Amplitude:	2mV to 20V peak-peak open circuit (1mV to 10V peak-peak into 50Ω) in four switch-selectable ranges with 20dB vernier control within each range.
Attenuator:	0, –20, – 40 or – 60dB.
DC Offset Range:	±10V. DC offset plus signal peak limited to ±10V (±5V into 50Ω); CLIP shows in display when offset + signal peak exceeds ±10V. DC offset plus waveform attenuated proportionally by the attenuator.

600Ω Main Out

Alternative output socket providing the same signal as the 50Ω Main Out but from 600Ω. The 50Ω and 600Ω sockets are not independent.

Aux Out

Output Characteristics:	Frequency, symmetry and phase the same as main outputs.
Output Level:	0 to 5V TTL/CMOS logic levels capable of driving 2 standard TTL loads.

Sweep Out

When internal sweep is selected the sweep signal is available as a 0 to 3V ramp from 600Ω.

INPUTS

Sweep In

The SWEEP IN/OUT socket is set to Sweep In when EXT SWEEP is selected.

Input Impedance:	10kΩ.
Input Sensitivity:	0 to 3V for 1000:1 sweep.
⚠ Maximum Allowable Input Voltage:	± 10V.
Sweep Linearity:	Better than 1%
Maximum Slew Rate of Sweep Voltage:	0·1V/µs.

AM In

The AM/COUNT IN socket is set to AM input when EXT AM is selected.

Input Impedance:	40kΩ.
Input Sensitivity:	Approximately 2V peak-peak for 50% modulation.
⚠ Maximum Allowable Input Voltage:	± 10V.

Count In

The AM/COUNT IN socket is set to external frequency measurement when EXT COUNT is selected.

Input Impedance:	1MΩ//25pF.
Input Sensitivity:	50mVrms (sinewave).
⚠ Maximum Allowable Input Voltage:	50Vdc/50Vrms to 400Hz with respect to ground ⏚ , reducing to 1Vrms above 1MHz.

DISPLAY FUNCTIONS

The LCD shows generator frequency simultaneously with output amplitude/offset, together with various status annunciators. Alternatively, it is the external frequency measurement display.

Internal Measurement Accuracy

Frequency:	Auto-ranging reciprocal measurement giving 4-digit resolution down to 10Hz (to 1Hz on the 5Hz range); resolution is fixed at 0·01Hz below 10Hz (0·001Hz below 1Hz on the 5Hz range). Accuracy is ± 1 digit to 2·1Hz (to 0·21Hz, Symmetry off, or to 0·42Hz, Symmetry on, on the 5Hz range); below this the accuracy is ± 1% of range full scale (unspecified with Symmetry on).
Amplitude:	Display shows peak-to-peak amplitude or rms value. Display corrected for attenuator setting. 3-digit resolution, accuracy typically ±5% of range full scale.
DC Offset:	3-digit resolution; accuracy typically ±2% setting ± 1 digit. Display corrected for attenuator setting.

External Frequency Measurement

Frequency Range:	5Hz to 20MHz, fully autoranging.
Input Sensitivity:	50mVrms (sinewave).
Measurement Time:	Selectable 0·5s or 5s.
Resolution:	6 digits in 0·5s; 7 digits in 5s.
Accuracy:	± 1 digit ± timebase accuracy.
Timebase Accuracy:	± 10ppm initial error; ±5 ppm/year ageing rate; typically less than 0·5 ppm/ºC.

GENERAL

POWER REQUIREMENTS

AC Input Voltage:	230V or 115V nominal, 50/60Hz, by internal adjustment; operating range ± 14% of nominal. Installation Category II.
Power Consumption:	25VA max.
Operating Range:	+5°C to +40°C, 20% to 80% RH.
Storage Range:	-10°C to +65°C
Environmental:	Indoor use at altitudes up to 2000m, Pollution Degree 1.
Size:	260 (W) x 88 (H) x 235 (D) mm (10.2 x 3.4 x 9.2") excluding handle and feet.
Weight:	1.9kg (4.2lb).
Safety:	Complies with EN61010-1.
EMC:	Complies with EN50081-1 and EN50082-1.

Safety

This instrument is Safety Class I according to IEC classification and has been designed to meet the requirements of EN61010-1 (Safety Requirements for Electrical Equipment for Measurement, Control and Laboratory Use). It is an Installation Category II instrument intended for operation from a normal single phase supply.

This instrument has been tested in accordance with EN61010-1 and has been supplied in a safe condition. This instruction manual contains some information and warnings which have to be followed by the user to ensure safe operation and to retain the instrument in a safe condition.

This instrument has been designed for indoor use in a Pollution Degree 1 environment (no pollution, or only dry non-conductive pollution) in the temperature range 5°C to 40°C, 20% –80% RH (non-condensing). It may occasionally be subjected to temperatures between +5° and –10°C without degradation of its safety.

Use of this instrument in a manner not specified by these instructions may impair the safety protection provided. Do not operate the instrument outside its rated supply voltages or environmental range. In particular excessive moisture may impair safety.

WARNING! THIS INSTRUMENT MUST BE EARTHED

Any interruption of the mains earth conductor inside or outside the instrument will make the instrument dangerous. Intentional interruption is prohibited. The protective action must not be negated by the use of an extension cord without a protective conductor.

When the instrument is connected to its supply, terminals may be live and opening the covers or removal of parts (except those to which access can be gained by hand) is likely to expose live parts. The apparatus shall be disconnected from all voltage sources before it is opened for any adjustment, replacement, maintenance or repair.

Any adjustment, maintenance and repair of the opened instrument under voltage shall be avoided as far as possible and, if inevitable, shall be carried out only by a skilled person who is aware of the hazard involved.

If the instrument is clearly defective, has been subject to mechanical damage, excessive moisture or chemical corrosion the safety protection may be impaired and the apparatus should be withdrawn from use and returned for checking and repair.

Make sure that only fuses with the required rated current and of the specified type are used for replacement. The use of makeshift fuses and the short-circuiting of fuse holders is prohibited.

Do not wet the instrument when cleaning it.

The following symbols are used on the instrument and in this manual:-

Caution - refer to the accompanying documentation, incorrect operation may damage the instrument.

terminal connected to chassis ground.

alternating current.

This generator has been designed to meet the requirements of the EMC Directive 89/336/EEC.

Compliance was demonstrated by meeting the test limits of the following standards:

Emissions

EN50081-1 (1992) Generic emission standard for residential commercial and light industry. Test methods and limits used were:

a) EN55022 Conducted, Class B

b) EN55022 Radiated, Class B

Immunity

EN50082-1 (1992) Generic immunity standard for residential, commercial and light industry. Test methods and limits used were:

a) EN60801-2 (1993) Electrostatic Discharge, 8 kV air discharge.

b) IEC801-3 (1984) RF Field, 3 V/m.

c) IEC801-4 (1988) Fast Transient, 1 kV peak (AC line), 0·5kV peak (signal lines).

Cautions

To ensure continued compliance with the EMC directive the following precautions should be observed:

a) connect the generator to other equipment using only high quality, double-screened cables.

b) after opening the case for any reason ensure that all signal and ground connections are remade correctly before replacing the cover. Always ensure all case screws are correctly refitted and tightened.

c) In the event of part replacement becoming necessary, only use components of an identical type, see Parts List.

Installation

Mains Operating Voltage

The operating voltage of the instrument is shown on the rear panel. Should it be necessary to change the operating voltage from 230V to 115V or vice-versa, proceed as follows:

1. Disconnect the instrument from all voltage sources.
2. Remove the 4 screws which hold the upper and lower case halves together and lift off the case lower.
3. Remove the 6 screws securing the main pcb to the case upper and lift the pcb free, complete with front and rear panels.
4. Change the appropriate zero-ohm links beside the transformer on the pcb:

   Link LK2 only for 230V operation

   Link LK1 and LK3 only for 115V operation
5. Refit the pcb to the case upper, ensuring all connections (especially safety earth) are remade as before, and refit the case lower.
6. To comply with safety standard requirements the operating voltage marked on the rear panel must be changed to clearly show the new voltage setting.
7. Change the fuse to suit the new operating voltage, see below.

Fuse

The correct time-lag fuse must be fitted for the selected operating voltage.

For 230V operation use 125mA (T) 250V HBC.

For 115V operation use 250mA (T) 250V HBC.

Make sure that only fuses with the required rated current and of the specified type are used for replacement. The use of makeshift fuses and the short-circuiting of fuse holders are prohibited.

Mains Lead

When a three core mains lead with bare ends is provided it should be connected as follows:

Brown	**-**	**Mains live**
Blue	**-**	**Mains Neutral**
Green/Yellow	**-**	**Earth**

WARNING! THIS INSTRUMENT MUST BE EARTHED

Any interruption of the mains earth conductor inside or outside the instrument will make the instrument dangerous. Intentional interruption is prohibited.

Service Handling Precautions

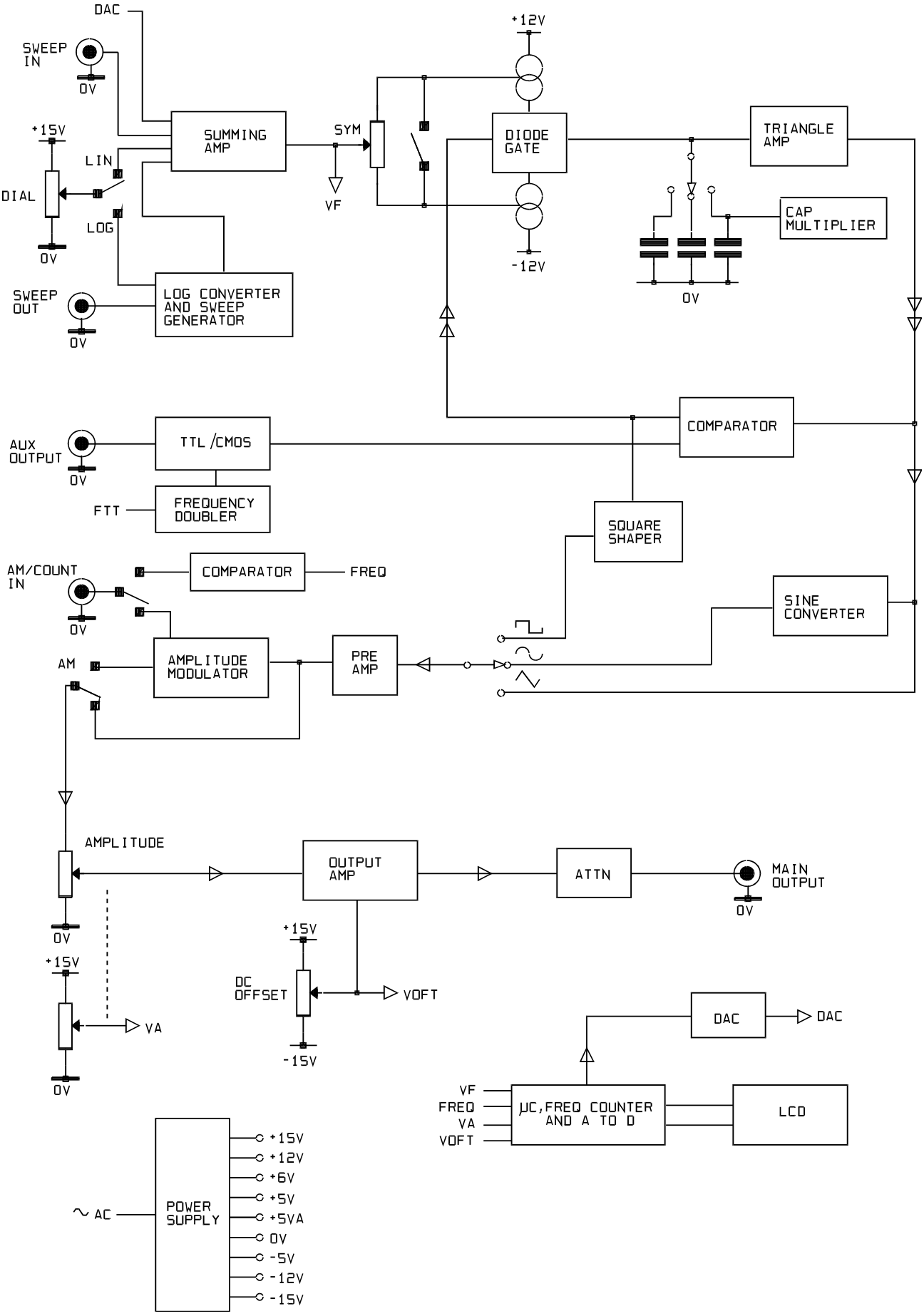
Service work or calibration should only be carried out by skilled engineers. Please note the following points before commencing work.

The tracks on the printed circuit board are very find and may lift if subjected to excessive heat. Use only a miniature temperature controlled soldering iron and remove all solder (on both sides of the joint) with solder wick or suction before attempting to remove a components.

Many of the integrated circuits are CMOS devices and are should be taken when handling to avoid damage by static discharge.

Dismantling the instrument

1. Invert the instrument and remove the 4 screws next to the rubber feet.
2. Lift off the case lower ensuring the front and rear panels stay with the case upper.
3. Remove the 6 screws securing the main pcb to the case upper and lift the pcb free, complete with front and rear panels.
4. To remove the control pcb from the front panel, first pull off the small knobs and unplug the two flat cable assemblies. Then desolder all other wire connections between main and control pcbs (at the control board end), lift the assembly clear and undo the 8 screws which hold the control board to the front panel; the control board can then be removed.
5. To gain access to the microcontroller the LCD must be removed.
6. The rear panel can be removed by undoing the tamper-proof safety earth connection.
7. Reassemble in the reverse order taking care to remake connections exactly as before, particularly the safety earth wiring.



Functional Block Diagram

Functional Description

The relationships between the major circuit elements are shown in the block diagram.

The summing amplifier sums the voltages from the dial, the frequency lock DAC, sweep input and the internal sweep circuit and its output controls the magnitude of the complimentary current source and current sink. This current varies from approximately 4·3uA to 4·3mA for a 1000:1 frequency change (·005 to 5·0). The symmetry control adjusts the ratio between the current source and current sink.

The diode gate steers current into and out of the range multiplier capacitor and is controlled by the comparator output. When the comparator output is high the charge on the capacitor will rise, linearly, producing the positive going triangle slope. When the comparator output is low the charge on the capacitor will fall linearly producing the negative going triangle slope.

The triangle amplifier has unity gain and buffers the triangle wave on the multiplier capacitor to drive the comparator and output circuits.

The comparator operates as a window detector with fixed limit points set to the triangle peaks. One of its two outputs drives the TTL/CMOS output. The other output is level shifted to drive the diode gate and squarewave shaper. When the comparator output to the diode gate is high the triangle wave is positive-going until this reaches approximately +1V, when the comparator output switches low. When the comparator output is low the triangle wave is negative-going until it reaches approximately –1V, when the comparator goes high, and the cycle is repeated. This basic function generator loop is shown by the double arrows in the block diagram. Triangle and squarewave are generated simultaneously as shown.

To achieve the 500Hz, 50Hz and 5Hz ranges, the 5k range capacitor is multiplied by 10, 100 or 1000 by the capacitor multiplier circuit.

The sinewave converter uses the non-linear characteristics of a transistor pair to convert the triangle wave into a sinewave. The selected function is amplified by the pre-amp and applied to the amplitude control directly or via the amplitude modulator. The signal is summed with the voltage from the DC offset control at the output amplifier, which amplifies the signal up to 20V peak to peak to drive the main output socket.

The microcontroller measures and displays frequency directly down to 0·2Hz; below this the microcontroller's A to D converter measures the voltage at the summing amplifier and displays the corresponding frequency. Amplitude and offset are measured by the A to D converter too.

The sweep generator provides a triangle wave with variable amplitude and speed that is summed with the dial at the summing amplifier.

External Count In is amplified by a comparator and measured by the microcontroller.

The power supply converts the incoming AC line voltage to the DC rails required by the instrument.

Power Supply - DC Regulation

Diode bridge BR2 rectifies the full output of the transformer; C56 and C57 are the reservoir capacitors which supply the ± 15V regulators. Fine adjustment is provide by VR23 and VR24.

The ± 12V rails are derived from the ± 15V rails with D31 and D32.

The +6V rail is derived from the +15V rail with D33.

IC39 is a 2.5V reference; IC41B generates +5VA, fine adjusted by VR38.

IC41C and D provide ± 12VA.

Diode bridge BR1 rectifies the lower output of the transformer; C131 and C132 are the reservoir capacitors which supply the ± 5V regulators.

Waveform Generation - Summing Amplifier and Current Sources

The dial and sweep voltages are summed by IC36B; the output range of the amplifier is approximately –4mV to –4V for a 1000:1 frequency change. Q1 gives increased current capability to drive R24 and R76. When the symmetry button is depressed R24 and R76 are increased by a factor of 10 with the symmetry control in mid-position, decreasing the output frequency by a factor of 10. This allows a symmetry range of 10:1.

IC2C refers the output of IC36B to the +12V rail; IC4 and Q4 mirror this into the diode gate. IC2A inverts the output of IC36B, IC2B refers it to the –12V rail, IC22 and Q18 mirror this into the diode gate.

Waveform Generation - Range Selection and Triangle Amplifier

Ranges 5kHz to 5MHz use decade steps of range capacitor. The lower three ranges use a capacitance multiplier. The capacitance multiplier steals current from the capacitor via R101.

The triangle amplifier uses Q7 as a source follower and Q8 as a current source; Q7 and Q8 are Idss matched. Q9 and Q10 are emitter followers to give two low impedance outputs. The stage has unity gain and the offset is trimmed by VR14.

Waveform Generation - Comparator and Aux Output

IC5 operates as a window detector and determines the peak to peak amplitude of the triangle wave on the range capacitor, which is approximately ± 1V. Capacitors C15 to C20 compensate for comparator delay ensuring that the triangle wave amplitude remains constant with increase in frequency. The two internal NAND gates in IC5 are wired as a flip-flop to ensure positive switching of the comparator.

Q6 level shifts the output of IC5 to be about ground, to drive the diode gate. IC6 drives the Aux Output with a TTL/CMOS compatible signal.

Waveform Generation - Waveform Shaping

The sine shaper comprises a monolithic transistor array IC17 which is driven by the triangle amplifier. The circuit has two non-linear stages. A pair of emitter followers A and D round the peaks of the triangle; the output of this stage is impressed across R103 and R108 in series and applied to the second stage. This comprises a differential pair B and C driven almost into cut-off and converts the clipped triangle into a sinewave. VR10 adjusts the gain of this pair to bring them close to cut off, minimising sinewave distortion. VR11 adjusts the dc operating point of the sinewave converter to give symmetrical operation on both positive and negative halves of the waveform.

The squarewave shaper is a diode bridge D36 to D39, driven by a level shifter Q26, which steers current into and out of R91 and C32. This gives a clean waveform which is symmetrical about ground. When squarewave is not selected SW10A gates the signal off at IC6B.

Preamplifier

The waveform selected by IC14 passes to the preamplifier IC18. The 1·8V pk to pk output is connected to the Amplitude control via the AM switch.

Output Amplifier

Q21 and Q22 are complementary emitter followers and buffer the output of IC19.

The DC Offset control is buffered by IC23A and IC23C and applied via R120 and R175.

Amplitude Modulator

When the AM button is depressed, the amplitude modulator is inserted between the preamplifier and the output amplifier. IC21 is a balanced modulator. IC24 is a differential amplifier which amplifies the difference between the open collector outputs of IC21. The circuit around IC37 forms a 400Hz oscillator the output is passed through a Sallen and Key low pass filter IC20B. IC20A buffers the signal on the modulation depth control VR33 and also sets the dc bias for IC21.

Sweep – Ramp Generator

The rate control VR31 determines the magnitude of the current source IC7A and Q12. This current is steered into and out of C25 by the operational transconductance amplifier (OTA) IC8. The voltage on C25 is buffered by IC7B to drive the stop control VR35 and the window comparator IC10A and IC10B. The thresholds of the window comparator determine the limits of the ramp which are 0V and +4V. Q13 and Q14 are level shifters to drive flip flop IC12A. The output of IC12A is level shifted by R74 and R57 and clamped by D5 and D4 to be symmetrical about 0V. When the input to IC8 is high the OTA sources current into C25; when the input is low the OTA sinks current from C25. This loop is very similar to a function generator. If either the set start or set stop buttons are depressed the loop is closed around the ramp generator forcing the ramp to be held precisely at its lower or upper limit. IC10D buffers the signal on VR21 to drive the main board directly or via the log converter.

Sweep – Log Converter

IC3D sums the output of the ramp generator with an offset current to drive the logging transistors IC13A and IC13B. Temperature compensation of the log converter is by TDR1 which has a temperature coefficient of +0·3%/°C. The log converter itself simply uses the exponential relationship between Vbe and collector current. IC13 is a matched transistor array. The right-hand transistor is the logging transistor and its emitter is driven by the input voltage via the left-hand transistor which compensates for the logging transistor Vbe. The left hand transistor's collector current is defined by R16 and is held constant by IC3A; its Vbe is therefore constant and so the input voltage at the junction of R19 and TDR1 is impressed across the Vbe of the logging transistor. The logarithmic change in collector current of the logging transistor is converted into a voltage by IC3B. The log converter is actually an antilog converter.

Digital Display

IC30 is a microcontroller that provides frequency and voltage measurement and displays the results on the LCD. In frequency measurement mode IC29-A outputs the GATE signal, which is controlled via the J (START) and K (STOP) inputs. The GATE is synchronised to the positive edges of the input signal. Whilst GATE is high IC30 counts the internal reference clock and IC29-B outputs the input signal divided by two, which is also counted by IC30. When GATE goes low the frequency is calculated and displayed.

Voltage measurements are made via the A-D inputs RA0 (pin 5), RA1 (pin 6) and RA3 (pin 9). RA0 input measures the amplitude voltage (VA). RA1 input measures the Frequency Dial voltage (VF) which is used to display low frequency measurements. RA3 input measures the offset voltage (VOFT).

IC31 is a DAC that outputs a correction voltage to IC3-C when frequency lock is selected. This correction voltage is adjusted by IC30 to maintain frequency lock.

IC35 and IC38 are multiplexers that are used by IC30 to input the instrument status; IC30 updates the display with the correct settings.

Calibration

Equipment Required

Oscilloscope

Distortion Meter

4·5 digit Multimeter

Reciprocal counting Frequency Meter

Only the case lower need be removed to gain access to all adjustments. Allow 1 hour warm-up (with the case lower in place) before commencing. For best results, use the following procedure.

1. **Power Supply**

+15V ± –20mV - VR23	–15V ± 20mV - VR24
+12V ± 0·5V	–12V ± –0·5V
+5V ± 0·25V	–5V ± –0·3V
+5VA ± 20mV - VR38	+6V ± 0·5V

2. **Offset Nulling**

Select: 5k range, frequency vernier to 3·0, sweep OFF.

IC	TP	Adjust	DVM Reading
4	2	VR6	<40µV
22	3	VR7	<40µV
16	6	VR13	<40µV

3. Nulling of the triangle amplifier is achieved by shorting its input (TP5) and adjusting VR14 to give <2mV on TP4.

4. **Preamplifier and Output Amplifier DC Offsets**

Ensure that the DC offset control is at its centre detent. Release all three function buttons. Amplitude control to minimum, adjust VR16 for <5mV at the main output.

Amplitude control to maximum, adjust VR15 for <5mV at the main output.

5. **Waveform Symmetry**

5k range, vernier at approximately 4, squarewave, adjust VR8 for equal mark:space ratio using the oscilloscope x10 X-multiplier to increase resolution and the trigger slope switch.

5M range, vernier to approximately ·005 to give 5kHz to 6kHz, adjust VR5 for equal mark:space ratio.

6. **Frequency Calibration**

Connect the Frequency Counter to AUX output.

Select external count and apply a frequency standard to AM/COUNT IN, select 5 sec gate time if required and adjust VC2 through the front panel for the correct reading ± 2 ppm.

Select internal count and remove the frequency standard.

Dial fully clockwise, 5kHz range, note the reading on the internal frequency counter.

500Hz range, adjust VR12 for one tenth of the above reading ± 5 digits.

5kHz range, adjust verniers for 5Hz.

50Hz range, adjust VR36 for 00·05.

Fit shorting link to TP1 and adjust the verniers for 18·0Hz on the external counter.

Adjust VR37 for 1·80 on the display.

Remove TP1 short.

7. **Sinewave Distortion**

Select sinewave, 5k range, 3kHz. Adjust VR10 and VR11 for minimum distortion. Adjust VR9 for the output to be symmetrical about 0V.

8. **AM**

500k range, approximately 300kHz, sinewave, modulation to minimum, amplitude to maximum (20V pk-pk).

Select AM, check output drops to half (10V pk-pk) adjusted by VR18.

Modulation to maximum, adjust VR17 for 100% modulation.

Release all 3 function buttons, increase the oscilloscope gain and adjust VR19 for minimum output of the 400Hz modulation source.

Adjust VR20 for 0V ± 50mV output. Turn AM off.

9. **Meter Calibration**

Calibration of the frequency meter was covered in 6 above.

Display select to amplitude, 5k range, squarewave, adjust the amplitude control to give 16V pk-pk (8V pk-pk into 50Ω) then adjust VR28 on the control board for 1600 on the display.

Display select to offset, release all 3 function buttons, amplitude to minimum, offset control at centre detent, connect a multimeter to the main output, adjust VR22 so that both meters read the same.

Offset control fully clockwise, adjust VR21 so both meters read the same, ±1%.

10. **Sweep**

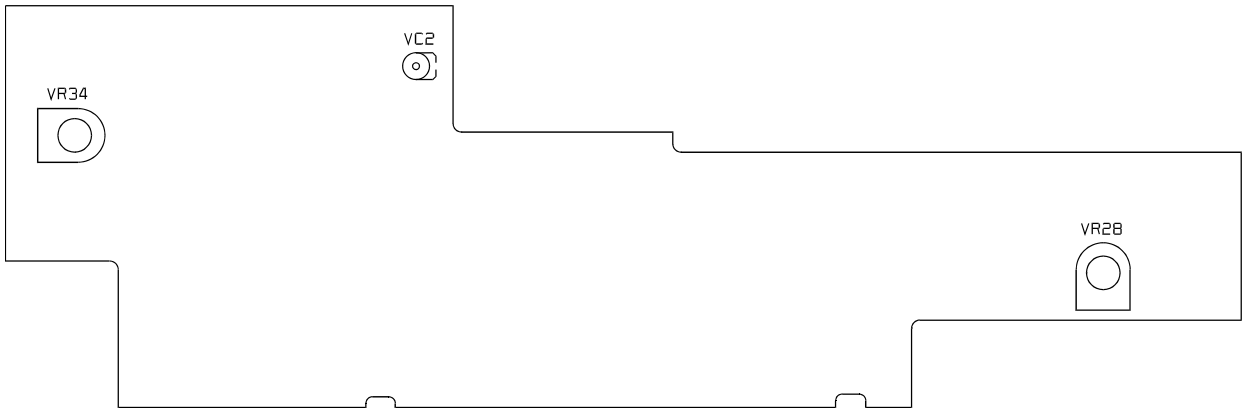
Sweep to ON, LIN stop control to maximum, 5M range, vernier to minimum (·005), hold in, set start and adjust VR2 for 4·3kHz to 4·8kHz. Select LOG, hold in set start and adjust VR4 for 4·3kHz to 4·8kHz. Select 500k range, hold in, set stop and adjust VR3 for 500kHz.

VR34 on the display board adjusts display contrast.

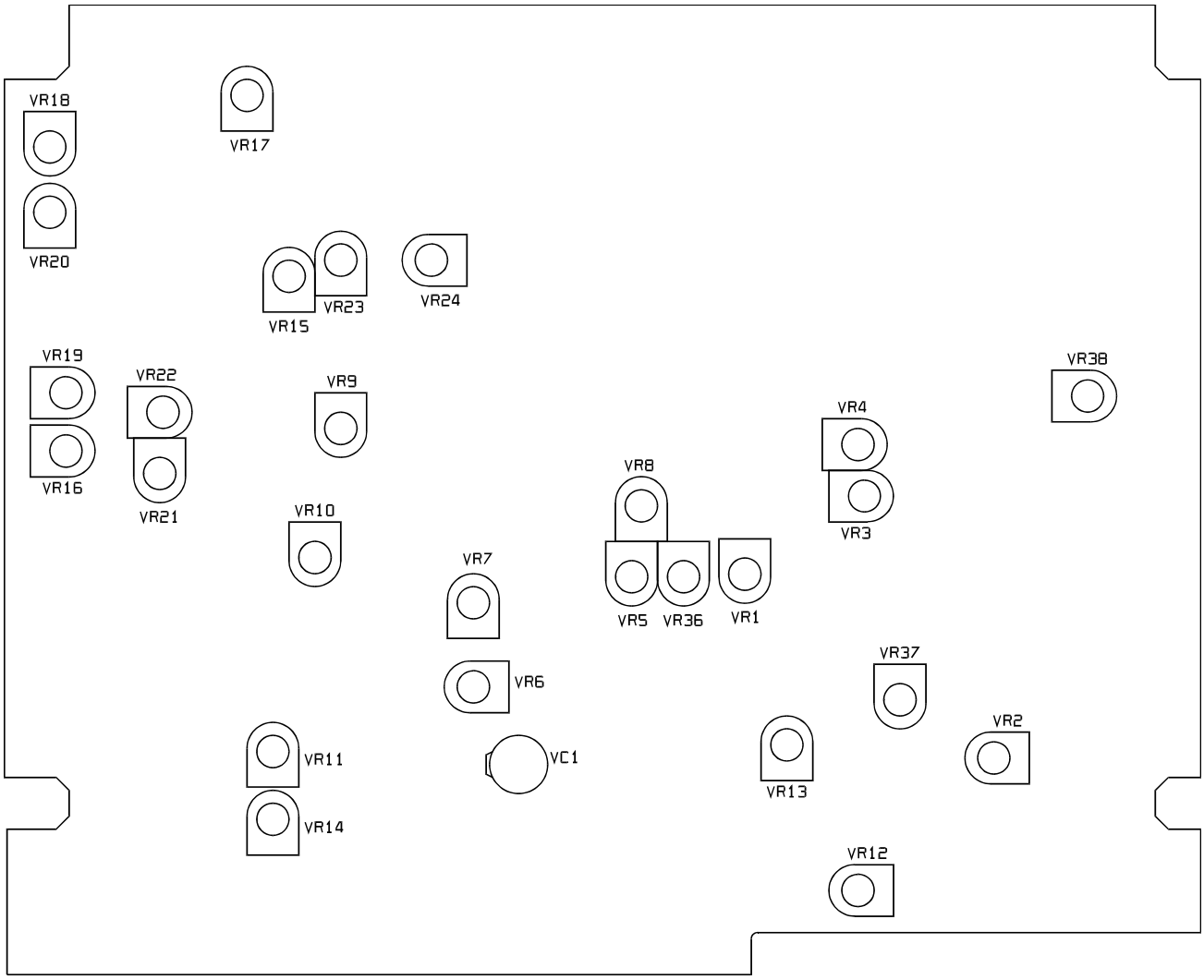
11. **Power Consumption**

230V <100mA

115V <200mA



Control Board – Calibration Points



Main Board – Calibration Points

PCB ASSY MAIN (44912-0450)

Part No.	Description	Position
20205-0610	STUD M3 X 10 KFH-M3-10ET	FOR PJ2
20613-0007	WASHER (SIL-PAD) TO220 PLAIN	FOR IC25,26
20661-0801	SPACER TRANSISTOR MTG TO5	FOR Q21,22
20670-0040	HEATSINK TO5 48DEG C/W	FOR Q21,22
20670-0135	CLIP GP02 FOR PCB MTG H/SINKS	FOR IC25,26
20670-0320	HEATSINK PCB MTG 50MM PLAIN	FOR IC25,26
22040-0901	BEAD FERRITE FX1115	FB1-5
22115-0390	TRANSFORMER	T1
22219-0120	SWITCH ROCKER SPST R/A	PCB MNT SW26
22225-0760	SWITCHBANK X 13	SW1-13
22312-0260	FUSEHOLDER PCB MOUNT	FOR FS1
22315-0239	FUSE 125MA TL HRC	FS1
22315-0450	FUSE 500mAT SUBMIN PCB MNT	FS2-5
22520-0160	AC RECEP 10AMP R/ANG	PJ2
22573-0041	HEADER 2 WAY STRAIGHT	TP1-6
22573-9110	HEADER 36W STR SIL TIN	PJ6 (9 WAY), PJ7 (5 WAY)
22575-0064	HEADER 26 WAY (2X13) STR SKEL	PJ1
22575-0103	HEADER 16 WAY (2X8) STR SKELTN	PJ5
23185-0000	RES ZERO OHM	LK2
23185-6120	RES 12M0J W25 CF	R4
23202-0100	RES 10R0F W25 MF 50PPM	R92
23202-0270	RES 27R0F W25 MF 50PPM	R53
23202-0470	RES 47R0F W25 MF 50PPM	R31,102,112,144
23202-0750	RES 75R0F W25 MF 50PPM	R163
23202-0910	RES 91R0F W25 MF 50PPM	R118
23202-1100	RES 100RF W25 MF 50PPM	R10,35,90,148,149
23202-1120	RES 120RF W25 MF 50PPM	R116,162
23202-1124	RES 124RF W25 MF 50PPM	R43,44
23202-1150	RES 150RF W25 MF 50PPM	R48,58,65
23202-1180	RES 180RF W25 MF 50PPM	R110
23202-1191	RES 191RF W25 MF 50PPM	R91
23202-1200	RES 200RF W25 MF 50PPM	R128-131
23202-1220	RES 220RF W25 MF 50PPM	R38,41,46,119,179,180
23202-1226	RES 226RF W25 MF 50PPM	R108
23202-1330	RES 330RF W25 MF 50PPM	R36

PCB ASSY MAIN (44912-0450) continued/…

Part No.	Description	Position
23202-1340	RES 340RF W25 MF 50PPM	R106
23202-1402	RES 402RF W25 MF 50PPM	R229
23202-1470	RES 470RF W25 MF 50PPM	R37
23202-1510	RES 510RF W25 MF 50PPM	R155,156
23202-1620	RES 620RF W25 MF 50PPM	R24,25,75,76
23202-1680	RES 680RF W25 MF 50PPM	R114
23202-1681	RES 681RF W25 MF 50PPM	R42,45
23202-1715	RES 715RF W25 MF 50PPM	R26,29,77
23202-1820	RES 820RF W25 MF 50PPM	R32,121
23202-1910	RES 910RF W25 MF 50PPM	R30,83
23202-2100	RES 1K00F W25 MF 50PPM	R33,49,84,88,101,158
23202-2110	RES 1K10F W25 MF 50PPM	R103
23202-2120	RES 1K20F W25 MF 50PPM	R34
23202-2137	RES 1K37F W25 MF 50PPM	R82
23202-2143	RES 1K43F W25 MF 50PPM	R78,81
23202-2150	RES 1K50F W25 MF 50PPM	R39,40,89,122,126
23202-2160	RES 1K60F W25 MF 50PPM	R120,175
23202-2180	RES 1K80F W25 MF 50PPM	R52,
23202-2200	RES 2K00F W25 MF 50PPM	R115,161
23202-2220	RES 2K20F W25 MF 50PPM	R17,59,74,87,159,171,172,176,177, 178,181-183,186,187,227,238
23202-2249	RES 2K49F W25 MF 50PPM	R136
23202-2300	RES 3K00F W25 MF 50PPM	R50,54,150
23202-2402	RES 4K02F W25 MF 50PPM	R63,152
23202-2430	RES 4K30F W25 MF 50PPM	R21,231
23202-2510	RES 5K10F W25 MF 50PPM	R226
23202-2560	RES 5K60F W25 MF 50PPM	R157
23202-2665	RES 6K65F W25 MF 50PPM	R147
23202-2680	RES 6K80F W25 MF 50PPM	R153,233
23202-2750	RES 7K50F W25 MF 50PPM	R18,232
23202-3100	RES 10K0F W25 MF 50PPM	R1,8,11,13,14,23,60,61,66,68, 70-72, 79, 85, 86, 93, 96, 98, 107, 142, 146, 164,168,170,173,207,239
23202-3107	RES 10K7F W25 MF 50PPM	R19
23202-3110	RES 11K0F W25 MF 50PPM	R2,62,138,139,140
23202-3120	RES 12K0F W25 MF 50PPM	R12,151,167
23202-3127	RES 12K7F W25 MF 50PPM	R47,

PCB ASSY MAIN (44912-0450) continued/…

Part No.	Description	Position
23202-3130	RES 13K0F W25 MF 50PPM	R145,223
23202-3150	RES 15K0F W25 MF 50PPM	R57,105,109,113
23202-3220	RES 22K0F W25 MF 50PPM	R97,165,184,235
23202-3226	RES 22K6F W25 MF 50PPM	R104
23202-3249	RES 24K9F W25 MF 50PPM	R111
23202-3270	RES 27K0F W25 MF 50PPM	R22
23202-3300	RES 30K0F W25 MF 50PPM	R16,69,154,234
23202-3330	RES 33K0F W25 MF 50PPM	R15,185
23202-3360	RES 36K0F W25 MF 50PPM	R3,228
23202-3390	RES 39K0F W25 MF 50PPM	R7,9
23202-3430	RES 43K0F W25 MF 50PPM	R143
23202-3470	RES 47K0F W25 MF 50PPM	R55,141
23202-3510	RES 51K0F W25 MF 50PPM	R6
23202-3560	RES 56K0F W25 MF 50PPM	R117,169
23202-4100	RES 100KF W25 MF 50PPM	R27,28,64,94,166,188,230
23202-4110	RES 110KF W25 MF 50PPM	R225
23202-4180	RES 180KF W25 MF 50PPM	R56
23202-4270	RES 270KF W25 MF 50PPM	R80,224
23202-5100	RES 1M00F W25 MF 50PPM	R95,189
23202-5470	RES 4M70F W25 MF 50PPM	R20
23202-6100	RES 10M0F W25 MF 50PPM	R5,174
23206-0102	RES 10R2F W60 MF 50PPM	R134
23206-0412	RES 41R2F W60 MF 50PPM	R132,133
23206-0510	RES 51R0F W60 MF 50PPM	R135,137
23206-1600	RES 600RF W60 MF 50PPM	R73
23215-3100	RES 10K0B W25 MF 15PPM	R236,237
23222-0100	RES 10R0J W33 MF FUSIBLE NFR25	R9
23377-1100	RES PS/H 100R CF 10MM	VR8
23377-1470	RES PS/H 470R CF 10MM	VR14,20,23,24
23377-2100	RES PS/H 1K0 CF 10MM	VR12,38
23377-2220	RES PS/H 2K2 CF 10MM	VR21
23377-3100	RES PS/H 10K CF 10MM	VR3,6,7,9,13,18,22,37
23377-3220	RES PS/H 22K CF 10MM	VR2,4,5,11,19,36
23377-3470	RES PS/H 47K CF 10MM	VR15,16,17
23379-1100	RES PS/H 100R CERMET 10mm skel	VR10
23387-1680	RES 680RJ .25S TEMPERATURE DEP	TDR1

PCB ASSY MAIN (44912-0450) continued/…

Part No.	Description	Position
23424-0443	CAP 10NZ 1KV CER D10 P5	C55,130
23424-0459	CAP 4N7 250V AC CER STR/LNG Y	C124,125
23427-0268	CAP 22PJ 100V CER NPO P2.5	C17,32,112,113,121
23427-0331	CAP 1N0K 63V CER HI K P5T	C135
23427-0385	CAP 39PJ 100V CER NPO P2.5	C109
23427-0593	CAP 82PG 100V CER NPO P2.5	C16,18
23427-9205	CAP 47PJ 100V CER NPO P2.5	C11
23427-9236	CAP 18PJ 100V CER NPO P2.5	C15
23428-0100	CAP 10PG 100V CER NPO P2.5	C3,23,26,27,28,88,89
23428-1100	CAP 100PG 100V CER NPO P2.5	C2,111,136
23557-0647	CAP 10U 35V ELEC RE2 P2	C53,54,60-66,94,95,117,137,138
23557-0664	CAP 1000U 35V ELEC RE2 P5	C56,57,131,132
23620-0236	CAP 1N0K 100V P/E P5	C68
23620-0245	CAP 4N7K 63V P/E P5	C38
23620-0246	CAP 100NK 63V P/E P5	C1,4,10,12-14,21,22,29-31,34,36,37, 41-52,67,90,91,96-98,101105,108,119, 120,123,139,140
23620-0252	CAP 2N2K 63V P/E P5	C40
23620-0256	CAP 1U0K 63V P/E P5	C25
23620-0266	CAP 680NK 63V P/E P5	C118
23620-9007	CAP 10NK 100V P/E P5	C39
23662-0110	CAP 100NK 63V P/C P5	C35
23662-0203	CAP 150PJ 100V P/C FKC2 P5	C5
23662-0205	CAP 330PK 100V P/C FKC2 P5	C7
23662-0240	CAP 1N50J 100V P/C FKC2 P5	C6
23662-0300	CAP 3N3J 100V P/C P5	C19,20
23662-0310	CAP 22N0J 100V P/C P5	C8
23662-0330	CAP 220NJ 100V P/C P5	C9
25021-0901	DIO 1N4148 B/R	D1-7,12-19,27,28,35
25031-0020	DIO BAT81	D8-11,36-39
25115-0907	DIO 1N4002 B/R	D29,30,43,44
25130-0911	DIO ZEN 3V0 W4	D31,32
25130-9202	DIO ZEN 9V1 W5	D33
25130-9206	DIO ZEN 6V8 W5	D22
25211-9302	RECTIFIER BRIDGE W02G	BR1,2
25336-5590	TRAN PNP BC559C	Q1,2,4,9,10,11,12,17,20
25344-0500	TRAN PNP 2N2905A	Q22

PCB ASSY MAIN (44912-0450) continued/…

Part No.	Description	Position
25377-0700	TRAN NPN 2N2219A	Q21
25377-5490	TRAN NPN BC549C	Q3,5,13-16,18,19,26
25381-0404	TRAN NPN 2N3904T	Q6
25601-0103	TRAN FET BF245AT	Q7,8
25601-0400	TRAN MOSFET N CHAN ZVN3306A	Q25
27106-0505	IC CA3080E	IC8
27106-0506	IC LM324N1	IC2,3,10,41
27106-0513	IC LM358N	IC36
27106-0518	IC MC3403P	IC23
27106-0548	IC TSH10IN	IC18,24
27106-0604	IC TL071CP	IC15,16
27106-0606	IC TL072CP	IC7,20
27106-0608	IC LF351N	IC4,22
27106-0641	IC CLC430A	IC19
27151-0110	IC MC1496P	IC21
27160-0009	IC V/REG 7805	IC27
27160-0014	IC V/REG 7905	IC28
27160-0200	IC V/REG LM317	IC25
27160-0210	IC V/REG LM337	IC26
27160-0900	IC V/REG 431	IC39
27164-0503	IC CA3046	IC13,17
27223-0740	IC 74LS74	IC12
27226-0110	IC 4011B	IC37
27226-0530	IC 4053B	IC1,9
27229-0000	IC 74HCT00N	IC6
27230-0520	IC 74HC4052	IC14
27254-0010	IC NE521N	IC5
35555-2730	PCB – MAIN	

PCB ASSY – CONTROL (44912-0460)

Part No.	Description	Position
22225-0220	SWITCH PUSH/PUSH SPPH11470B	SW15-19
22226-0101	KEYSWITCH – ALPS SKHHBW	SW20-25
23105-2470	RES SM0805 4K70F W1	R242-247
23202-0270	RES 27R0F W25 MF 50PPM	R201
23202-1100	RES 100RF W25 MF 50PPM	R215

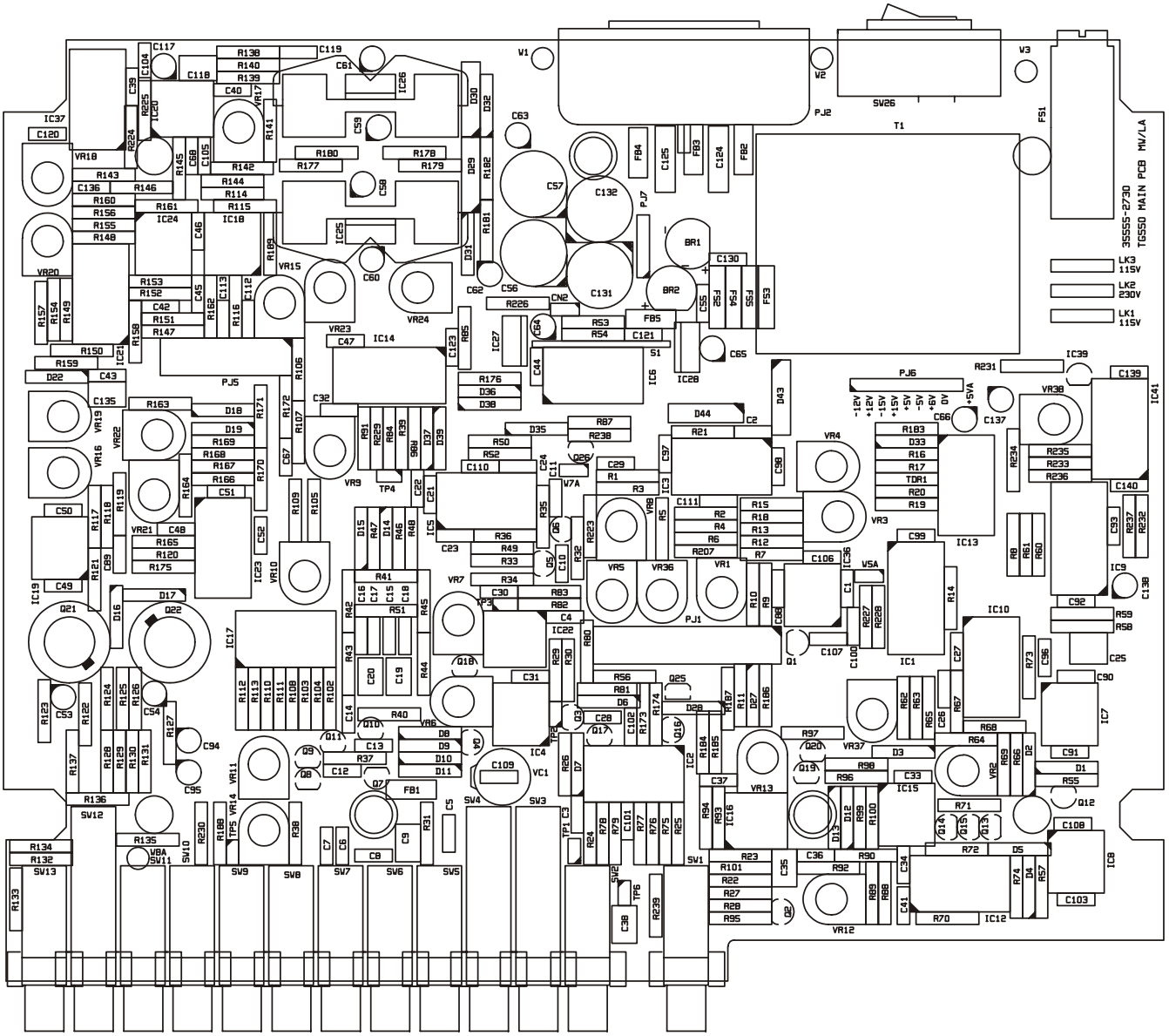
PCB ASSY – CONTROL continued/…

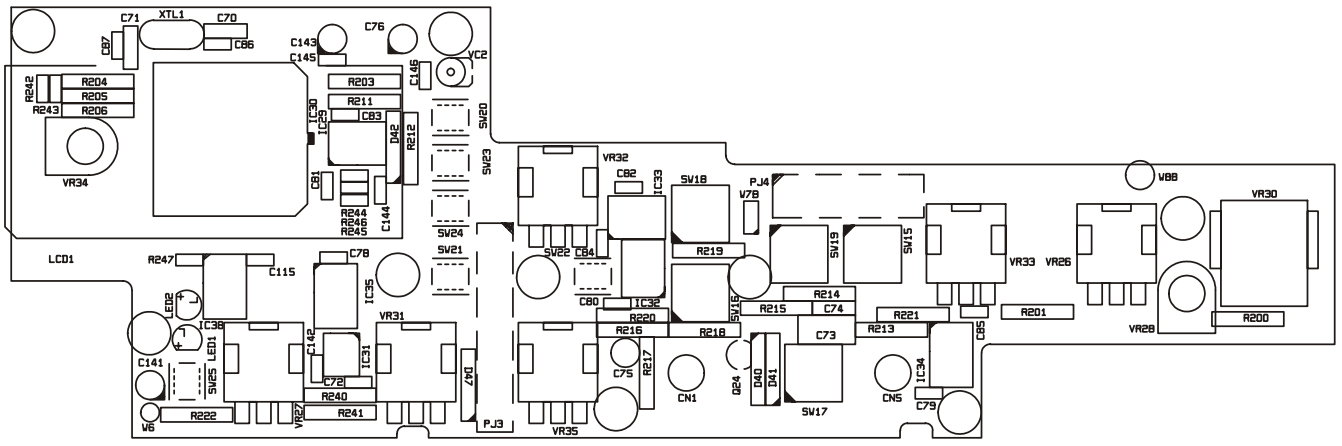
Part No.	Description	Position
23202-1150	RES 150RF W25 MF 50PPM	R200
23202-2100	RES 1K00F W25 MF 50PPM	R211,217,218,222
23202-2220	RES 2K20F W25 MF 50PPM	R203
23202-2470	RES 4K7OF W25 MF 50PPM	R216
23202-3100	RES 10K0F W25 MF 50PPM	R204,205,206,240,241
23202-3300	RES 30K0F W25 MF 50PPM	R212,221
23202-4100	RES 100KF W25 MF 50PPM	R214,219
23202-4200	RES 200KF W25 MF 50PPM	R220
23202-5100	RES 1M00F W25 MF 50PPM	R213
23377-1220	RES PS/H 220R CF 10MM	VR28
23377-3100	RES PS/H 10K CF 10MM	VR34
23347-0140	POT 10K LIN VO12L-PV25F-B10K	VR27,32,33,35
23347-0350	POT 500K LOG FLAT SHAFT 25MM	VR31
23347-0360	POT 10K LIN DETENT FLAT SHAFT	VR26
23347-0530	POT 1K + 1K GANGED V/PCB MOUNT	VR30
23427-9209	CAP 33PJ 100V CER NPO P2.5	C70
23427-9205	CAP 47PJ 100V CER NPO P2.5	C71
23450-0036	CAP 47PK 500V 5MM DIA P5	C74
23461-0020	CAP SM0805 100NZ 50V CER Y5V	C72,78-86,115,142,144-146
23557-0505	CAP 10U 16V ELEC RC2 P1.5	C76,141,143
23557-0658	CAP 100U 25V ELEC RE2 P2.5	C75
23633-0002	CAP 100NJ 250V P/E UNCOAT P7.5	C73
23984-0017	TRIMCAP 4-20P 5MM GREEN	VC2
25021-0901	DIO 1N4148 B/R	D42,47
25030-0905	DIO BA482 B/R	D40,41
25601-9007	TRAN FET (NJ) J309	Q24
25061-0200	LED – T1 ROUND (3MM) – RED	LED1,2
26100-0220	LCD	LCD1
27153-1040	IC SM TLC5615CD 10-BIT DAC	IC31
27236-0530	IC SM 74HC4053	IC34
27238-0000	IC SM 74HCT00	IC33
27239-1070	IC SM 74HC107	IC29
27239-1510	IC SM 74HC151	IC35,38
27250-2110	IC SM PIC16C924-08L PLCC	IC30
27254-1008	IC SM 75107	IC32
28500-9008	XTAL – 8MHZ – MICROPROCESSOR	XTL1
35555-2740	PCB – CONTROL	

CASE PARTS

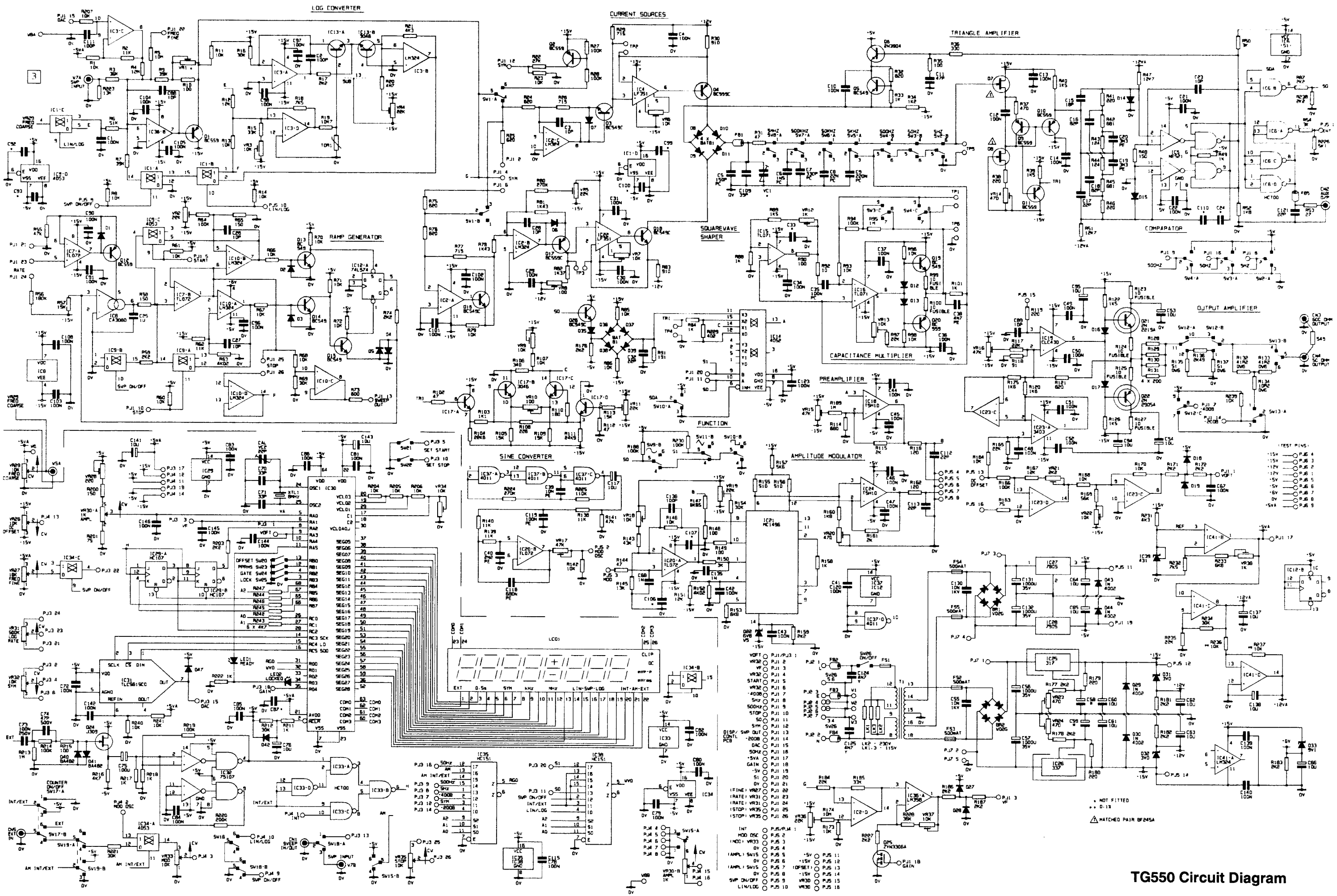
Part No.	Description	Position
20038-9502	WASHER M4 SPRING	REAR PANEL EARTH
20038-9501	WASHER M3 SPRING	MAIN PCB/CASE UPPER, CONTROL PCB/FRONT PANEL, FRONT PANEL EARTH
20037-0401	SOLDER TAG SHAKEPROOF - 4BA	REAR PANEL EARTH
20037-0400	SOLDER TAG SHAKEPROOF - 6BA	FRONT PANEL EARTH
20030-0266	WASHER M4 ZPST	REAR PANEL EARTH
20030-0263	WASHER M3 ZPST	FEET, FRONT PANEL EARTH
20065-0030	SCREW N0 4 X 3/8 PLASTT PNHDPZ	MAIN PCB/CASE
20210-0102	NUT M4 ZPSTREAR PANEL	EARTH
20210-0101	NUT M3 ZPST	REAR PANEL EARTH
20662-0540	FOOT MOULDED GREY	
20234-0027	SCREW M3 X 6 PNHDPZ ZPST	CONTROL PCB/FRONT PANEL
20236-0010	SCREW M4 X 12 TAMPERPROOF	REAR PANEL EARTH
20661-0258	SPACER Rnd 7/32 IDx1/4 L Nyl	MAIN PCB/CASE UPPER
20612-0011	WASHER FIBRE M3	MAIN PCB/CASE UPPER, CONTROL PCB/FRONT PANEL
23202-1549	RES 549RF W25 MF 50PPM	OUTPUTS
22491-0120	MAINS LD 2M ST IEC/UK PLUG 5A	FOR UK
22491-0270	MAINS LD 2M ST IEC/EURO PLUG	FOR EUROPE
22588-0004	BNC SKT BKHD 50R STANDARD	
23348-0701	WASHER SHK/PROOF	
23347-0175	POT 10KA OW20BU F11 X 15	
33331-4980	REAR PANEL PRINTED	
33331-4970	OVERLAY FRONT PANEL	
33331-4960	FRONT PANEL	
33536-3820	CASE LOWER - RFI SCREENED	
33536-3810	CASE UPPER - RFI SCREENED	
31336-0250	HANDLE BENCH INST CASE	
37113-2010	KEYCAP	
37113-0400	BUTTON, MID-GREY ABS	
37151-0390	KNOB 12.5MM D-SHAFT MID GREY	
37151-0380	KNOB 21MM D-SHAFT MID GREY	
37113-0170	BUTTON, SWITCHBANKS, MID-GREY	
48591-0560	INSTRUCTION BOOK	

Component Layouts





Circuit Diagram


LOG CONVERTER
CURRENT SOURCES
TRIANGLE AMPLIFIER
RAMP GENERATOR
SQUAREWAVE SHAPER
COMPARATOR
CAPACITANCE MULTIPLIER
OUTPUT AMPLIFIER
PREAMPLIFIER
FUNCTION
SINE CONVERTER
AMPLITUDE MODULATOR
COUNTER
LCD1
TG550 Circuit Diagram

Thurlby Thandar Instruments Ltd
Glebe Road, Huntingdon, Cambridgeshire PE29 7DR, England
Telephone: (44) 01480 412451 Fax: (44) 01480 450409
e mail: sales@tti-test.com web site: www.tti-test.com